Oroville FERC Relicensing (Project No. 2100)

Environmental Work Group

July 28, 2004

SP-F10 Tasks 1D and 1E

Evaluation of Oroville Facilities operations on water Temperature-Related Effects on Pre-Spawning Adult Chinook Salmon and Characterization of Holding Habitat

SP-F10, Tasks 1D and 1E

Need for Study

- **The Oroville Facilities affect instream water temperatures in the lower Feather River, which influence spring-run Chinook salmon holding habitat and use patterns.**

Study Objective

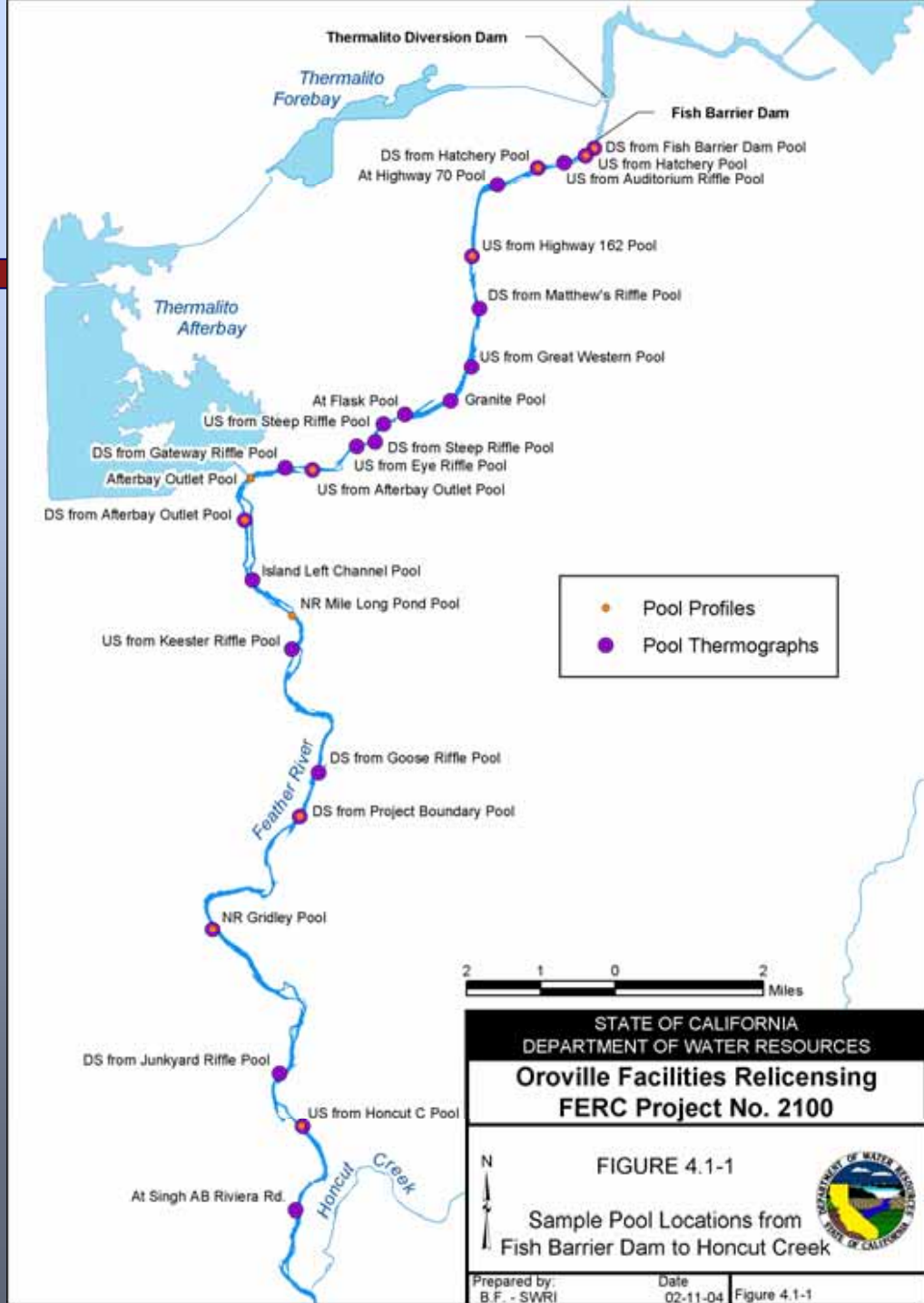
- **Together the objectives of SP-F10 Tasks 1D and 1E were to evaluate the water temperature related effects on pre-spawning adult Chinook salmon, holding habitat, and habitat use patterns.**

Related Study Plans

- **SP-F10 Task 1E**
  - **DWR performed a spring-run Chinook salmon radio tracking experiment to determine habitat use patterns in the lower Feather River.**
- **SP-F10 Task 2B**
  - **Examined the adult pre-spawn mortality rate for Chinook salmon in the lower Feather River.**
- **SP-F10 Task 2C**
  - **USBR Early Life Stage Mortality Model**
    - **Examined affects of water temperature on in vivo egg mortality in pre-spawning adult Chinook salmon**

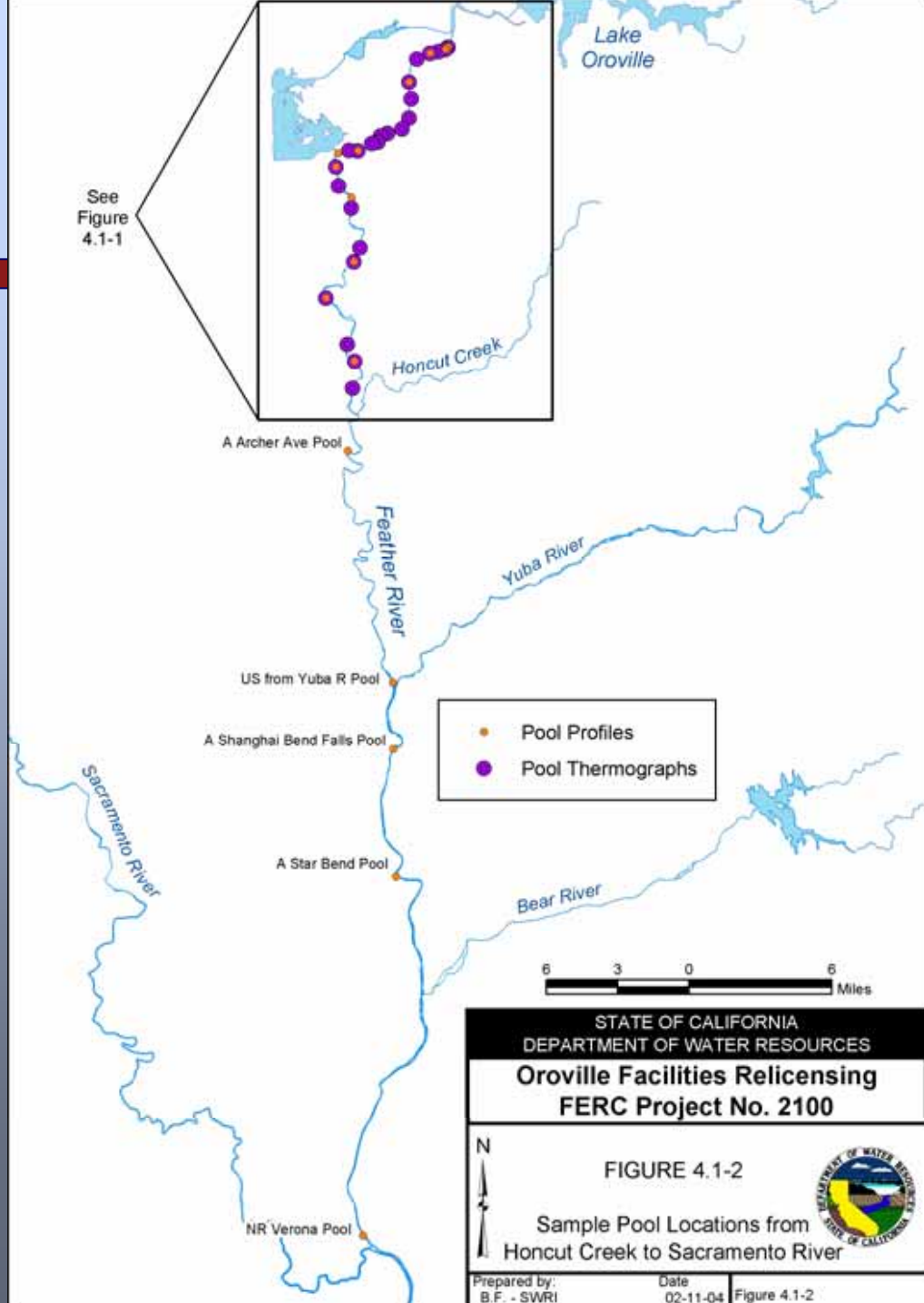
Introduction
Study Area

- **Feather River from the Diversion Dam to Confluence with the Sacramento River**



Introduction
Study Area

- **Feather River from the Diversion Dam to Confluence with the Sacramento River**



Methodology
Study Design

- **Define Holding Period:**
  - **Literature review and anecdotal information suggests March through October.**
- **Define Suitable Substrate:**
  - **Literature review suggests that suitable pools have bedrock bottoms. Adult salmon avoid cobble, gravel, sand and silt substrates.**
  - **Little evidence that holding adult Chinook salmon prefer bedrock substrates. It is possible that those are the only substrates that exist in pools where holding adult Chinook salmon have been observed.**

Methodology
Study Design

- **Define Suitable Cover:**
  - **Literature review suggests that holding Chinook salmon need suitable cover such as rocky ledges, bubble curtains under which to seek shade as well as velocity refuges.**
  - **It is possible that pools in which observations of holding Chinook salmon occurred had those types of cover, but it is not clear to what extent cover is needed if water temperatures and water velocities are suitable.**
- **Define Suitable Water Velocity:**
  - **Literature review suggests that holding adult Chinook salmon utilize pools with water velocities between between 0.49 ft/sec and 2.6 ft/sec.**

Methodology
Study Design

- **Define Suitable Dissolved Oxygen (DO) Concentration:**
  - **Interim Report**
    - **EPA 30-day mean water column DO concentration for protection of non-juvenile life stages is 6.5 mg/L.**
  - **Final Report**
    - **No DO concentration criterion was used and no DO concentration analysis was performed.**

Methodology
Study Design

- **Define Suitable Water Temperature Range – Interim Report:**
  - **Literature review suggests that chronically exposed adult Chinook salmon in different regions have different water temperature tolerances.**
  - **The endpoints of water temperature ranges reported by Marine (1992) were used as indices of when effects could potentially occur in chronically exposed broodstock.**
    - **6°C - 14°C optimal broodstock survival, maturation and spawning**
    - **15°C - 17°C sublethal effects could potentially occur**
    - **17°C - 20°C upper incipient lethal water temperature is assumed to be within this range**

Methodology
Study Design

- **Define Suitable Water Temperature Range – Final Report:**
  - **Literature review of source studies and regulatory documents was conducted to determine reported water temperatures at which effects could occur.**
  - **Index values to which observed water temperatures could be compared selected based on the water temperatures reported in available literature.**

Methodology

Study Design

Index Value	Supporting Literature
60°F (15.6°C)	Maximum water temperature for adults holding, while eggs are maturing, is approximately 59°F to 60°F (NOAA Fisheries 1997a); Acceptable water temperatures for adults migrating upstream range from 57°F to 67°F (NOAA Fisheries 1997a); Upper limit of the optimal water temperature range for adults holding while eggs are maturing is 59°F to 60°F (NOAA Fisheries 2000); Many of the diseases that commonly affect Chinook salmon become highly infectious and virulent above 60°F (ODEQ 1995); Mature females subjected to prolonged exposure to water temperatures above 60°F have poor survival rates and produce less viable eggs than females exposed to lower water temperatures (USFWS 1995)
64°F (17.8°C)	Acceptable range for adults migrating upstream is from 57°F to 67°F (NOAA Fisheries 1997a); Disease risk becomes high at water temperatures above 64.4°F (EPA 2003); Latent embryonic mortalities and abnormalities associated with water temperature exposure to pre-spawning adults occur at 63.5°F to 66.2°F (Berman 1990)
68°F (20°C)	Acceptable range for adults migrating upstream range from 57 to 67°F (NOAA Fisheries 1997a); For chronic exposures, an incipient upper lethal water temperature limit for pre-spawning adult salmon probably falls within the range of 62.6°F to 68.0°F (Marine 1992); Spring-run Chinook salmon embryos from adults held at 63.5°F to 66.2°F had greater numbers of pre-hatch mortalities and developmental abnormalities than embryos from adults held at 57.2°F to 59.9°F (Berman 1990); Water temperatures of 68°F resulted in nearly 100 percent mortality of Chinook salmon during columnaris outbreaks (Ordal and Pacha 1963)

Methodology
Data Collection

- **Water Temperature and Dissolved Oxygen Concentration Data Collection – Interim Report:**
  - **Data were collected from 16 pools from April 30 – October 25, 2002.**
  - **Water temperature and DO measurements were recorded at half meter intervals.**
  - **Data was lost for most pools for April 30, all dates in May, June, and July, and August 7.**

Methodology
Data Collection

- **Water Temperature and Dissolved Oxygen Concentration Data Collection – Final Report:**
  - **Pool profile data were collected from the same 16 pools as those sampled in 2002 from March 20 – October 2, 2003.**
  - **Water temperature measurements were recorded at half meter intervals.**
  - **Pool thermograph data were collected at 24 pools from June to October.**
    - **Thermograph and profile data were collected from nine pools .**

Methodology
Data Analysis

- **Interim Report:**
  - **Suitable water temperature definition**
    - **Chose endpoints of temperature ranges reported in Marine (1992) as indices of potential effects to chronically exposed Chinook salmon.**
    - **15°C and 17°C were chosen as indices.**
      - **Water temperatures below 15°C were deemed suitable.**
      - **Water temperatures above 17°C were deemed unsuitable.**
      - **It is unclear whether water temperatures between 15°C and 17°C were suitable because that is the reported range in which sublethal effects to chronically exposed Chinook salmon may begin to occur.**

Methodology
Data Analysis

- **Interim Report:**
  - **DO concentration was considered suitable above 6.5 mg/L.**
  - **Substrate, Cover, and water velocity data were not analyzed.**
    - **Because it is unclear to what extent substrate and cover are important, these data will be analyzed with the results of the habitat utilization portion of this task.**
    - **Water velocity data was not requested in the original study plan.**

Methodology
Data Analysis

- **Final Report:**
  - **Water temperatures were compared to index values of 60°F (15.6°C), 64°F (17.8°C), and 68°F (20°C).**
  - **No judgment of suitability was made regarding the water temperatures in potential holding pools.**
  - **Determination of thermal barriers was made based on the index value of 70°F (21°C).**
  - **Daily mean water temperatures calculated from thermograph data were analyzed.**

Results
Dissolved Oxygen Concentration

- **Interim Report**
  - **At no time for which data exists does DO concentration in any pool drop below the EPA published thirty-day mean value for coldwater species adult life stages (6.5 mg/L).**
  - **Lowest value recorded was 8.5 mg/L**
- **Final Report**
  - **No analysis of dissolved oxygen was performed because the lowest value recorded in 2002 was well above the chosen criterion (EPA 30-day mean value).**

Results

Water Temperature – Interim Report

	04/30/02	05/16/02	05/30/02	06/12/02	06/27/02	07/15/02	07/25/02	08/07/02	08/22/02	08/26/02	09/05/02	09/26-27/02	10/8-9/02	10/24-25/02
Feather River downstream from Fish Barrier Dam Pool (Pool 1-1)	10.4	10.7	13.4	11.9	13.6	12.4	12.4		16.3	13.7	12.3	11.7	12.9	13.4
Feather River upstream from Hatchery Pool (Pool 1-2)	10.7	10.8	13.3	12.2	13.7	12.5	14.0		16.2	13.8	12.2	11.6	12.9	13.4
Feather River downstream from Hatchery Pool (Pool 1-3)	11.4	11.4	13.4	12.7	14.4	13.1	14.3		16.9	14.0	12.5	11.6	13.6	13.3
Feather R upstream from HWY 162 Bridge Pool (Pool 1-4)									18.0	14.9	14.0	11.6	14.7	13.3
Feather R US from Afterbay Outlet Pool (Pool 2-1)									18.4	16.2	14.8	13.3	15.0	13.8
Feather River at Afterbay Outlet Pool (Pool 2-2)									17.8	17.7	15.8	14.6	15.9	14.6
Feather R downstream from Afterbay Outlet Pool (Pool 3-1)									17.3	18.0	16.7	15.7	15.9	14.6
Feather R near Mile Long Pond Pool (Pool 3-2)									17.6	18.7	17.2	16.2	16.6	14.8
Feather R DS from Project Boundary Pool (Pool 3-3)									17.8	18.7	17.4	16.8	16.7	15.0
Feather R NR Gridley Pool (Pool 3-4)									17.7	19.0	17.1	16.7	16.5	14.8
Feather River Upstream from Honcut Creek(Pool 3-5)									17.7	19.2	16.8	16.6	16.3	14.7
Feather River at Archer Ave. Pool (Pool 4-1)									17.9	19.5	16.8	16.7	16.6	15.0
Feather River upstream from Yuba R. Pool (Pool 4-2)								20.0	18.6	20.1	17.2	17.9	17.0	14.9
Feather River at Shanghai Bend Pool (Pool 4-3)								18.7	18.5	19.4	17.4	18.0	17.0	14.8
Feather R A Star Bend Pool (Pool 4-4)								19.1	18.9	19.7	17.7	17.9	17.2	15.1
Feather R NR Verona Pool (Pool 4-5)								19.2	18.9	19.7	18.5	18.8	17.8	14.8

Water temperature (ºC)	Color code
6.0 - 14.9	
15.0 - 16.9	
Greater than 17.0	
No data	

Results

Water Column Temperature – Final Report

Station Name 2002	Sampling Event/Mean Water Column Temperature													Proportion of Sampling Events		
	4/30	5/16	5/30	6/12	6/27	7/15	7/25	8/7	8/22	8/26	9/5	9/26 - 9/27	10/8 - 10/9	10/24-10/25	≥15.6 °C (60°F)	≥17.8 °C (64°F)	≥20°C (68°F)
Feather R DS from Fish Barrier Dam Pool	10.4	10.7	13.4	11.9	13.6	12.4	12.4		16.3	13.7	12.3	11.7	12.9	13.4	8%	0%	0%
Feather R US from Hatchery Pool	10.7	10.8	13.3	12.2	14.4	13.1	14.3		16.2	13.8	12.2	11.6	12.9	13.4	8%	0%	0%
Feather R DS from Hatchery Pool	11.4	11.4	13.4	12.7	14.4	13.1	14.3		16.9	14	12.5	11.6	14.7	13.3	8%	0%	0%
Feather R US from Highway 162 Pool									18.0	14.9	14.0	11.6	14.7	13.3	0%	17%	0%
Feather R US from Afterbay Outlet Pool									18.4	16.2	14.8	13.3	15.0	13.8	17%	17%	0%
Feather River at Afterbay Outlet									17.8	17.7	15.8	14.6	15.9	14.6	50%	17%	0%
Feather R DS from Afterbay Outlet Pool									17.3	18.0	16.7	15.7	15.9	14.6	67%	17%	0%
Feather R N Mile Long Pond									17.6	18.7	17.2	16.2	16.6	14.8	67%	17%	0%
Feather R DS from Project Boundary Pool									17.8	18.7	17.4	16.8	16.7	15	50%	33%	0%
Feather R Near Gridley Pool									17.7	19	17.1	16.7	16.5	14.8	67%	17%	0%
Feather R US from Honcut C Pool									17.7	19.2	16.8	16.6	16.3	14.7	67%	17%	0%
Feather River at Archer Ave. Pool									17.9	19.5	16.8	16.7	16.6	15.0	50%	33%	0%
Feather River upstream from Yuba R. Pool								20.0	18.6	20.1	17.2	17.9	17.0	14.9	29%	29%	29%
Feather River at Shanghai Bend Pool								18.7	18.5	19.4	17.4	18.0	17.0	14.8	29%	57%	0%
Feather R A Star Bend Pool								19.1	18.9	19.7	17.7	17.9	17.2	15.1	29%	57%	0%
Feather R NR Verona Pool								19.2	18.9	19.7	18.5	18.8	17.8	14.8	0%	86%	0%

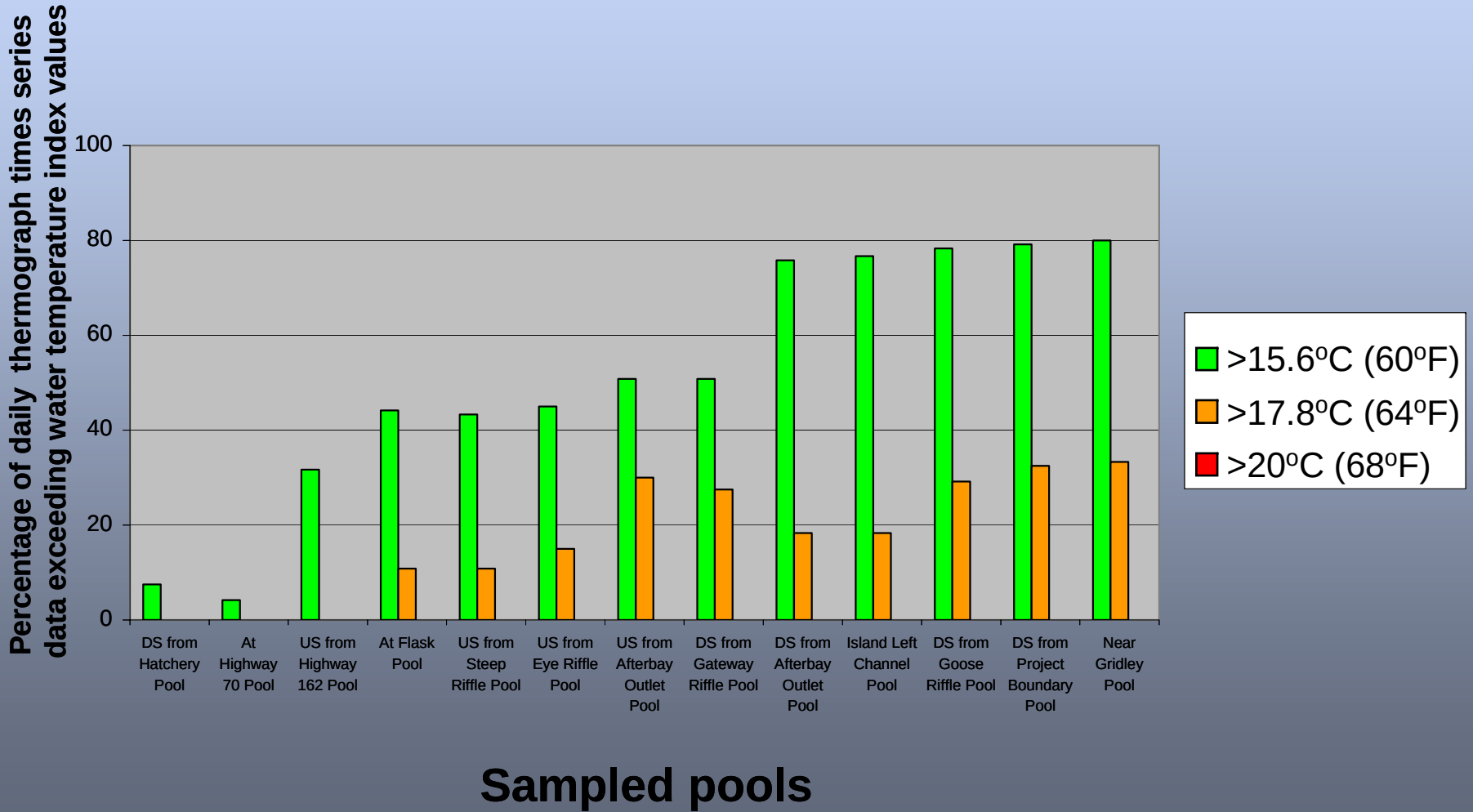
Results

Water Column Temperature – Final Report

Station Name 2003	Sampling Event/Mean Water Column Temperature														Proportion of Sampling Events		
	3/20 – 3/21	4/25	5/16	5/30	6/13	6/16	6/27 – 6/30	7/9 – 7/10	7/24 – 7/25	8/6 – 8/7	8/21 – 8/22	9/4 – 9/5	9/18 - 9/19	10/2	≥15.6 °C (60°F)	≥17.8 °C (64°F)	≥20°C (68°F)
Feather R DS from Fish Barrier Dam Pool	10	10.2	11.5	13.2		14.7	15.1	15.9	14.9	15.4	13.6	11.7	11.6		8%	0%	0%
Feather R US from Hatchery Pool	10	10.3	11.7	13.2		14.8	15.1	15.9	15.1	15.5	13.6	11.8	11.6		8%	0%	0%
Feather R DS from Hatchery Pool	9.7	10.5	12.2	14.2		15.6	15.6	16.7	15.6	15.9	13.8	12.6	12.2		42%	0%	0%
Feather R US from Highway 162 Pool	9.8	10.9	13.2	15.2		16.8	15.8	17	16.2	15.8	13.9	13.3	13.1		42%	0%	0%
Feather R US from Afterbay Outlet Pool	11	11.3	14.6	16.2		18.1	18.8	18.4	17.6	17.4	15.5	16.2	14.3		25%	25%	0%
Feather River at Afterbay Outlet	12.7	12.9	17	17.3		19	20.2	17.4	18	17.3	16	16.3	16.2		58%	17%	8%
Feather R DS from Afterbay Outlet Pool		12.9	18.5	17.9		18.9	21	17.2	17.7	17.7	15.7	16.9	16.1		54%	27%	9%
Feather R N Mile Long Pond	14.7														0%	0%	0%
Feather R DS from Project Boundary Pool		13	18.8	17.5		19.6	21.4	17.1	17.9	18.1	16.1	17.1	16.3		46%	36%	9%
Feather R Near Gridley Pool	14.3	13.1	18.3	17.2		19.5	21.5	17.1	19.1	18.3	16.2	17.7	15.9		42%	33%	8%
Feather R US from Honcut C Pool	14.2	13.3	17.8	17.2		19.3	21.9	18.2	19.1	19	16.4	17.6	15.8		33%	42%	8%
Feather River at Archer Ave. Pool	15.1	13.2	17.8	17.1	19.4	19.9	21.6	18.2	19	19	16.5	17.2	16.1		31%	46%	8%
Feather River upstream from Yuba R. Pool	14.7	13.6	18.6	18.5	20.4	14.7	22.9	18.7	19.4	18.8	17.4	17.9	18.1		8%	58%	17%
Feather River at Shanghai Bend Pool	12.5	12.7	14.8	16.1	17.5	14.8	21.1	18.4	18.7	17.8	17.1		18.2		27%	36%	9%
Feather R A Star Bend Pool	12.8	12.7	14.8	15.7	17.2	15.6	21.2	18.6	19	18	17.1	18.2	18.2		25%	42%	8%
Feather R NR Verona Pool	12.9	12.9	16.1	17.9	17.9	16.8	21.4	18.5	19.2	18.6	18	18.6	18.3	18.8	8%	69%	8%

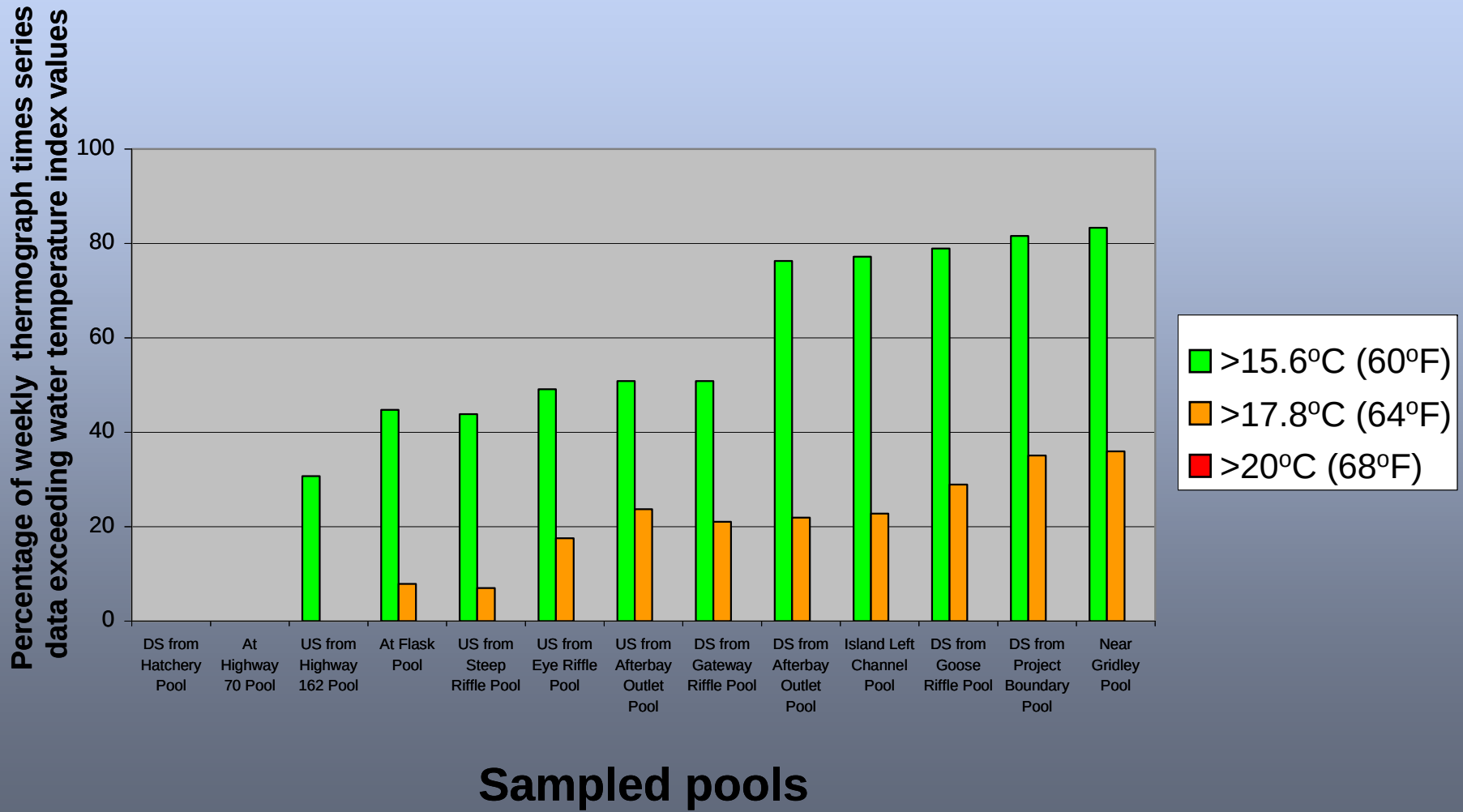
Results

Thermograph Water Temperature – Final Report



Results

Thermograph Water Temperature – Final Report



Discussion

- **Based on review of available literature and available water column temperature data, increased incidence of disease, developmental abnormalities, increased in-vivo egg mortality, and temporary cessation of migration could occur due to elevated water temperatures in some areas of the lower Feather River.**
- **Results of thermograph data analyses indicate that water temperatures generally are below those reported in the literature where profound individual or population effects occur. Additionally, daily and weekly mean water temperatures generally did not exceed the water temperatures reported to inhibit migration (21°C to 22°C (Berman and Quinn 1991)).**